BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: M. Tech   **SEMESTER:** II
BRANCH: Biotechnology   **SESSION:** SP / 22

SUBJECT: BE 506 BIOPROCESS PLANT DESIGN

TIME: 2 HOURS

INSTRUCTIONS:
1. Attempt all the questions
2. The missing data if any may suitably be assumed
3. Before attempting the question paper make sure you have got the correct paper.
4. Marks for questions are mentioned against each question.
5. Total mark for the examination is 50.

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1. Human serum albumin (HSA) is applied to stabilize blood volume during surgery and during shock or burn cases. It is also used for the formulation of protein therapeutics. One gram of HSA derived from human blood costs about USD$ 2 to 3.50. One of the disadvantages of extracting from human plasma to collect HSA is contamination of hepatitis viruses in blood. A Japanese company has designed a novel bioprocess using recombinant HSA (r-HSA), the gene of the HSA was cloned into *Pichia pastoria* (a yeast). The manufacturing flow sheet diagram was not available, but the brief description of the process was found by google search.

Draw a flow sheet diagram based on the statement below:

A 50,000L jacketed stirred tank bioreactor is used to grow the *P. pastoria* cells. In feed preparation portion, two separate stainless vessels were used to prepare sterilize medium. In the first vessel, glycine, water, basal salts and PTM1+vitamins solution were mixed. The second vessel is used for mixing diluted methanol and PTM1. The entire medium is fed into the bioreactor using pumps. After growing the cells for a desired time, the production of rHSA reached the maximum and the product is purified. The broth will pass through a microfiltration system to remove cells, then concentrated using a cross flow filtration system. A packed-bed adsorption (PBA) is then used to purify the product. The purified product is then cooled down and kept in storage tank before formulation. **[5 marks]**

2. Manufacture of sugar from sugarcane
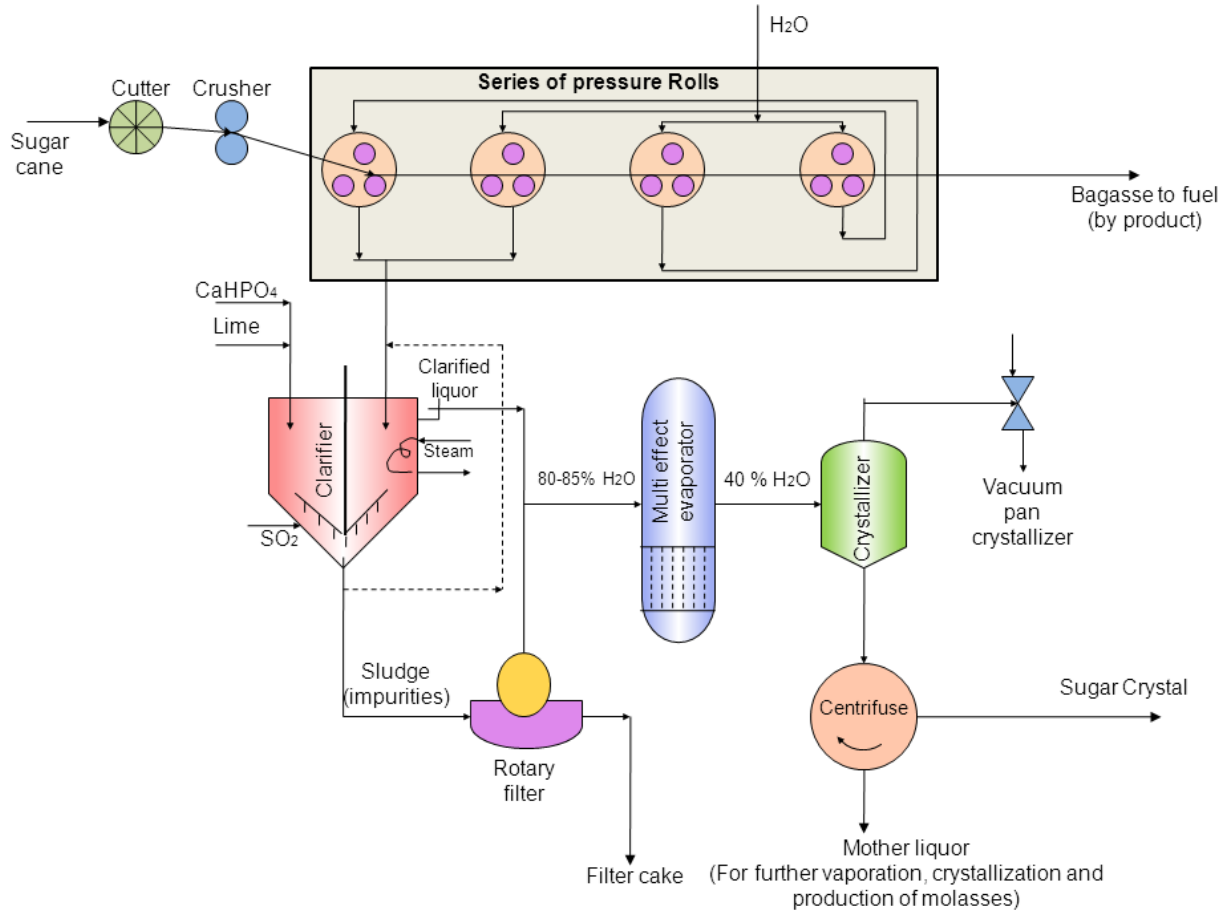
Sucrose ($c_{12}H_{22}O_{11}$) is a disaccharide that occurs naturally in most fruits and vegetables. Sugar occurs in greatest quantities in sugarcane and sugar beets from which sugar is separated economically and commercially. Loss of sucrose by inversion to glucose and fructose (monosaccharide) is represented by:

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$
Sugar   Glucose   Fructose
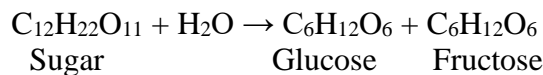
Manufacturing process of sugar from sugarcane is shown in the above flow sheet. Analyse the process of sugar production process and answer the following question

    a. What is special about the sugar production process from sugarcane? Analyse w.r.t to green technology. **[2 marks]**
    b. What are the by-products of sugar industries? **[2 marks]**

[Total 4 marks]

3. Selection of material is an important task in any process industry. Explain how you would plan for studying selection of material of construction. **[4 marks]**

4. Brief on the required characteristics of pipes and fittings in bio process industries. **[4 marks]**

5. Your team is designing a 1000-liter fermenter for a pilot scale operation. You are assigned the task of designing heat transfer equipment to the fermenter. You have the choice to choose between a jacketed type or an immersed coil type of heating. What are the factors you would consider in making your choice and why? **[4 marks]**

6. How do you define and characterize turbulence in fluid flow ? **[3 marks]**

7. The equation for Reynold number is given as $\mathrm{Re} = Du\rho / \mu,$
where D is the diameter for a pipe, u is the fluid flow rate ; ρ is the density of the fluid that pass through the pipe ; μ is the viscosity of the fluid that pass through the pipe.

      Starch solution (carbon source) was pumped into a bioreactor at a rate of 1 ml/min. The temperature for the starch solution at 37°C is 0.72 centipoise and the density at that temperature is 1.54 g/cm^3. The diameter of the tubing attached to the inlet of the bioreactor is 0.19 inch. Is the flow inside the tubing behaved as laminar (Re<2100) or a turbulent? **[3 marks]**

8. In designing a fermenter to produce antibiotic, your team task is to design heat exchanger for the fermenter. Your specific task is to find out the length of cooling coil of the heat exchanger required. The fermenter must be kept at 35^{0}C. After considering the oxygen demand of the organism and the heat dissipation from the stirrer, the maximum heat transfer rate required is estimated as 550 kW. Cooling water is available at 10^{0}C; the exit temperature of the cooling water is calculated using an energy balance as 25^{0}C. The heat transfer coefficient for the fermentation broth is estimated as 2150 W m^{-2} ^{0}C^{-1}. The heat transfer coefficient for the cooling water is calculated as 14 kW m^{-2} ^{0}C^{-1}. It is proposed to install a helical cooling coil inside the fermenter; the outer diameter of the pipe is 8 cm, the pipe wall thickness is 5 mm, and the thermal conductivity of the steel is 60 W m^{-1} ^{0}C^{-1}. An average internal fouling actor of 8500W m^{-2} ^{0}C^{-1} is expected; the fermenter-side surface of the coil is kept relatively clean.

a. What length of cooling coil would you recommend? [**4 marks]**

b. What are the prime design factors you would consider for design of heat exchangers in process industries? **[4 marks]**

9. Discuss the principal design concepts you will consider for design and operation of biohazard contaminant facilities. How will you plan your plant layout for a bioprocess industry to handle contaminants efficiently? **[5 marks]**

10. Discuss on validation of biotechnological process discussing the risk factors and analytical tools necessary for validation. **[5 marks]**

11. Answer the following MCQs**:** **[1x5=5 marks**]

i. Fixed capital investment of a chemical plant is the total amount of money needed to supply the necessary plant and manufacturing facilities plus the working capital for operation of the facilities. Which of the following components of fixed capital investment requires minimum percentage of it?
A) Electrical installation cost
B) Equipment installation cost
C) Cost for piping
D) Equipment insulation cost

ii. Which of the following is not a component of depreciation cost?
A) Repairs and maintenance cost

B) Loss due to obsolescence of the equipment
C) Loss due to decrease in the demand of product
D) Loss due to accident/breakdown in the machinery

iii. Fixed charges for a chemical plant does not include the
A) Interest on borrowed money
B) Rent of land and buildings
C) Property tax, insurance, and depreciation
D) Repair and maintenance charges

iv. Generally, income taxes are based on the
A) Total income
B) Gross earning
C) Total product cost
D) Fixed cost

v. Utilities cost in the operation of chemical process plant comes under the
A) Plant overhead cost
B) Fixed charges
C) Direct production cost
D) General expenses

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